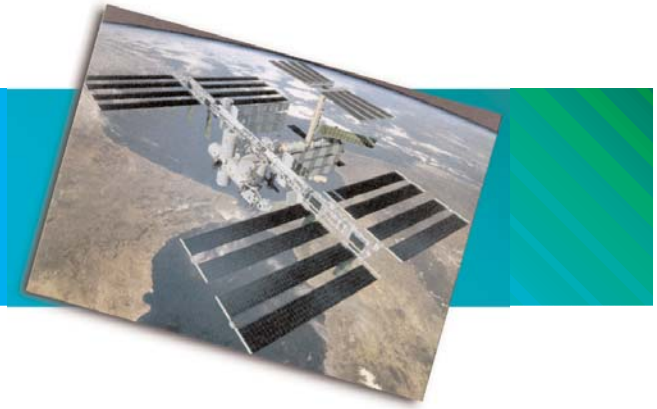


International Space Station



LEARNING OUTCOMES

After completing this chapter, you should be able to:

- Explain some of the research to be conducted on the ISS.
- Describe the living conditions on ISS.
- Name the nations involved with ISS.
- State the purpose of ISS.
- Describe the current status of ISS.
- Know the estimated timetable for completion.
- Identify some uses for the ISS.
- Locate when the ISS is traveling over your house.

take approximately 45 space flights, and several years to complete the assembly. The latest estimate projects a completion date of 2006.

Sixteen nations formed a global partnership to build the ISS. The United States and Russia have taken the lead, but the completion of the ISS will draw upon the scientific and technological resources of all sixteen countries. The other fourteen countries are: Belgium, Brazil, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. This cooperative agreement represents one of the largest non-military joint efforts in history.

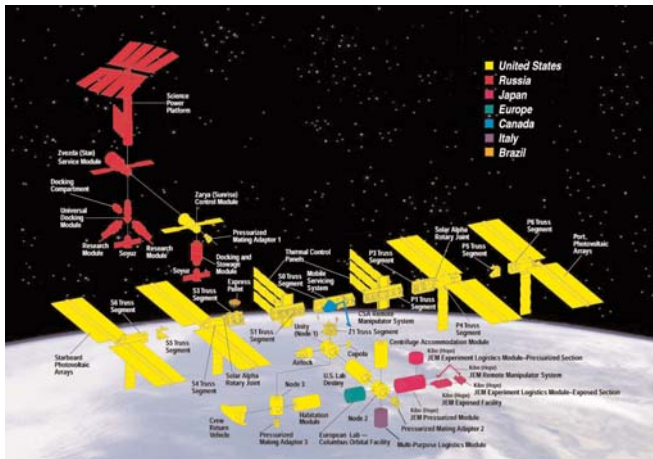


Background

In November 1998, a Russian rocket placed the Zarya module in orbit. This was the first flight toward the assembly of the ISS. In December of the same year, the United States launched the Space Shuttle Endeavor, which attached the Unity Module to Zarya, thus initiating the first ISS assembly sequence. Since then, twenty flights have traveled to the ISS. America's space shuttle and two Russian rockets will continue to deliver the various components to the space station. It will

Facts

This project is an engineering and scientific wonder ushering in a new era of human space exploration. More than 100 ISS elements will be assembled during the 45 missions with a mass of almost one million pounds (almost 500 tons). The ISS will measure 356 feet across and 290 feet long, and that doesn't count almost an acre (over 43,000 square feet) of solar panels. It will take approximately 160 space walks to assist in assembling the ISS. Plus, the astronauts will use a 58-foot robotic arm for moving large elements of the



assembly. A smaller robot arm, about 12 feet long, will also be used for more precise work and replacing smaller parts.

Fully assembled, the ISS will house a crew of up to seven. Depending on the size of the crew, the station will have one or two sleeping modules and six or seven laboratories for research. The space station will have four windows for conducting Earth observations, experiments, and other applications. There are also 11 external payload locations for mounting experiments.

The ISS is orbiting at about 250 miles above Earth at a speed of 17,500 mph. The ISS completes one orbit every 90 minutes; that's sixteen times a day. The altitude allows for launch vehicles from all of the international partners to provide to delivery of crews and supplies, and also provides for excellent Earth observations. The space station can view 85 percent of the globe and 95 percent of the population of Earth. In the activity portion of this chapter, you can use **J-TRACK** to locate the ISS and even discover when it travels

over your house. Additionally, in the Satellite chapter of this book, you can use Satellite Tool Kit (STK) technology to locate the ISS. Be sure to visit chapter 2 to see the amazing things you can do with STK.

Expedition 1 took the first crew to live onboard the space station in October 2000. That crew spent more than 138 days at the station. Since then, there have been several expeditions to the space station. As of this writing, the last mission-completed aboard the ISS was Expedition 8.

Expedition 8 conducted the first ever two-man spacewalk without a crewmember inside. The spacewalk had been scheduled for five and a half hours, but there was a malfunction with the Russian astronaut's space suit, so they returned inside after three hours. Before the spacewalk was over, the astronauts were able to install a device that will provide data on radiation exposure to the human body during space flight.



Russia's greenhouse experiment investigates plant development and genetics.



First ISS Crew: Cosmonaut Sergei Krikalev, Astronaut Bill Shepherd, and Cosmonaut Yuri Gidzenko.

Expedition 9 is conducting many science experiments and plans on two spacewalks that will perform modifications on the ISS exterior. Expedition 9 is scheduled to stay at the International Space Station for six months.

Life on the space station takes time to adjust to, but the ISS is designed to keep the astronauts comfortable. The modules are bright, roomy and are kept at 70° Fahrenheit at all times. In a typical workday, crewmembers spend 14 hours working and exercising, 1½ hours preparing and eating meals, and 8 ½ hours sleeping.

Space food has gotten much better over the years. The astronauts now have microwave ovens and refrigerators. Now they can eat more fruits



Crewmembers Malenchenko and Lu share a meal in the Zvezda Service Module.

and vegetables, and their diets are designed to supply each astronaut with 100 percent of the daily value of vitamins and minerals necessary for the environment of space.

Each crewmember has a private sleeping room. Because of no gravity, their beds are bolted down so they won't float away. Astronauts claim it is a great way to sleep. While in the space station, the astronauts can wear regular clothing and exer-



Crewmembers of the ISS must exercise daily.

cise daily to keep their muscles and bones from getting too weak.

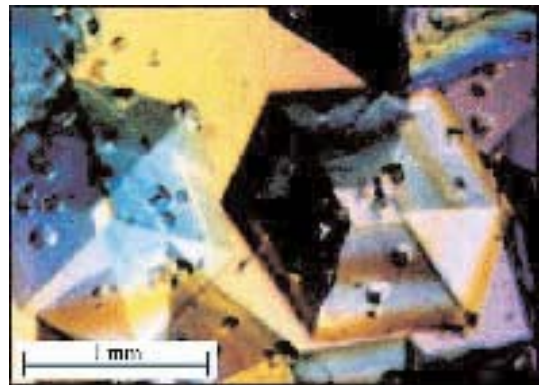
Potential Benefits

The international partners believe that the benefits from ISS research far outweigh the enormous costs of building the space station. For instance, ISS allows humans to live and study for long periods in microgravity, or a weightless environment. Since gravity influences almost every biological, physical, and chemical process on Earth, the space station gives us the unique opportunity to study a world without gravity. This will help us bet-

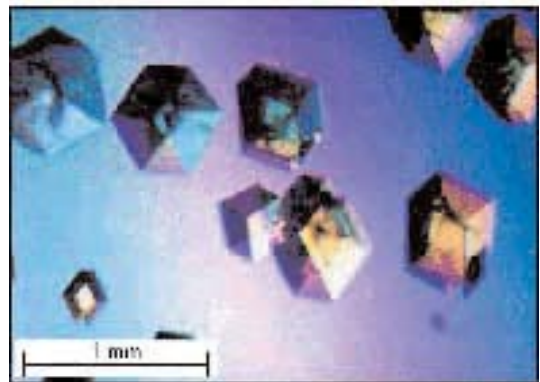
ter understand gravity's effects on plants, animals, and humans.

Without gravity, chemical reactions behave differently than they do on Earth. This means that molecules can be blended and substances created that would be impossible on Earth. These experiments may lead to possible treatments for diabetes, AIDS, cancer, and organ transplants. Watching the long-term effects of gravity in space will teach us about biological processes on Earth, such as aging and osteoporosis.

More pure protein crystals may be grown in



(a)



(b)

Crystals of insulin grown in microgravity, figure (a) were extremely well ordered and unusually large (many >2 mm) compared to those grown under identical conditions on the ground, figure (b).

space than on Earth. Analysis of these crystals helps scientists better understand the nature of proteins, enzymes and viruses, perhaps leading to the development of new drugs and a better understanding of the fundamental building blocks of life. This type of research could lead to the study of possible treatments for cancer, diabetes, emphysema, and immune system disorders, among other research. According to Astronaut Dan Bursch, "The National Institute of Health has said that pro-

tein crystal growth is the number one research tool that we'll be using in the next century....".

Living cells can be grown in a laboratory environment in space where they are not distorted by gravity. Growing cultures for long periods aboard the station will further advance this research. Such cultures can be used to test new treatments for cancer without risking harm to patients, among other uses.

Fluids, flames and molten metal and other materials will be the subject of basic research on the station. Flames burn differently without gravity. Reduced gravity reduces convection currents, and the absence of convection alters the shape of the flame in orbit. This allows for studying the combustion process in a way that is impossible on Earth. The absence of convection allows molten metals or other materials to be mixed more thoroughly in orbit than on Earth. Scientists plan to study this to create better metal alloys and more perfect materials for applications such as computer chips.

Observations of the Earth from orbit help study large-scale, long-term changes in the environment. These studies can increase our understanding of forests, oceans and mountains. These studies can also perceive atmospheric trends, climate changes and even view the effects of hurricanes, typhoons, and volcanoes. Also, air pollution, water pollution, deforestation, and how we use our land, mineral, and food resources can be seen and analyzed from space and can be captured in images that provide a global perspective unavailable from the ground.

In the field of biology, the scientists of the ISS will assist in answering some basic scientific ques-

tions in a different environment. For example, what is the role of gravity in the processes of biological evolution? Also, how does chronic exposure to altered gravity and other space related factors affect normal physiology, metabolism and function of mature organisms? These are just two of many theories in biological research.

Many of the new engineering technologies being developed on the ISS will lead to improved commercial space communication systems for personal phone, computer, and video use. They will also lead to improvements in energy efficiencies, air and water capabilities and new lower-cost building construction techniques. Advancements in space technology will significantly enhance the quality of life on Earth.

A very recent development is the Microgravity Science Glovebox, which Expedition 7 brought to the ISS. The glovebox is a sealed container that allows astronauts to perform hands-on experiments in a sealed environment. It works very well with certain fluids and materials that otherwise might be hazardous.

Research on the commercialization of space will also occur. Industries will participate in research by conducting experiments aimed at creating new products and services. The results may benefit us by providing innovative new products and creating new jobs to make the products.

Additionally, the space station is thought of as a stepping-stone to the stars. The ISS gives astronauts a much better opportunity to explore our solar system, as well as other distant galaxies. If humans are ever going to travel to other planets, such as Mars, we must understand the effects of such long journeys on the human body. We already know that living in microgravity leads to the weakening of bones and muscles. The space station will allow scientists to understand these effects and study solutions for long-term space travel.



Expedition Five flight engineer Peggy Whitson is shown with the Microgravity Science Glovebox following its installation in the Destiny



Tropical Storm Claudette was seen from the ISS as it turned into a hurricane that hit Houston and other areas in Texas July 15, 2003.

NASA continues to conduct space research to improve life on Earth. The benefits of space continue to provide advancements in science and technology.

More than 150 companies are partners with NASA in 15 research centers in developing meaningful, beneficial research.

Activity Section

Activity One

ENGLISH LANGUAGE ARTS (CAREERS) AND SCIENCE

Objective:

Explore certain careers associated with the International Space Station.

Materials:

Computer with Internet access, task cards, pencil/pen.

Estimated Time: 60 minutes

Background

There is a wide scope of opportunities in the field of aerospace. Many of these professions try to provide technologies that will add value to improve people's quality of life by strengthening the nation's economy, improving the environment, increasing our mobility and safety, and ensuring the continued national security. Many organizations work together to accomplish these goals including NASA, the Federal Aviation Administration, U.S. industry, the Department of Defense, and the university community.

The crews of the International Space Station (ISS) and the Space Shuttle have inspired many people to pursue careers as astronauts. However, the astronauts will tell you that their jobs would be impossible without the support people that work hard to make astronauts' jobs easier.

Many thousands of support staff provide skill and dedication to successful missions. Many are classified as aerospace technology workers, and their work falls into roles that include physical, life, and social scientists, pilots, mathematicians, engi-

neers, technicians, designers, and quality control inspectors. Many of these careers require a college degree with an emphasis on mathematics and science, but there are plenty of positions available to anyone with general knowledge and a desire to achieve.

Procedure/Activity:

1. Divide students/cadets into groups of three people - "engineers", "astronauts", and "scientists" - and provide each with a description of the job and some questions that relate to that job.
2. Students should research and answer questions; then share the answers with the rest of the group.

Rationale:

This lesson will provide a better understanding of some aerospace career fields.

Assessment:

Use a rubric to evaluate research skills and career knowledge.

Additional Information:

- ESL students should research someone involved in the aerospace industry from their part of the world.
- Have special needs students work with a group that will be supportive and assist with the information. These students can also research one question about one career or do a web graphic organizer.

Helpful web sites:

- <http://www.jsc.nasa.gov/news/factsheets/food.pdf> (food in space)
- <http://ftp.arc.nasa.gov/space/team/lel/jackson.html> (reliability engineer for ISS bio)
- <http://jsc-web-pub.jsc.nasa.gov/fpd/food.asp> (space food systems laboratory)

- <http://nasajobs.nasa.gov/astronauts/> (astronaut selection information)
- www.spaceflight.nasa.gov/outreach/jobsinfo/astronaut.html (how to become an astronaut)
- <http://www.scipoc.msfc.nasa.gov/> (ISS science operation news)
- http://www.nasaexplores.com/lessons/01-044/9-12_article.pdf (article containing the physical aspects of microgravity)
- http://quest.arc.nasa.gov/projects/astrobiology/astroventure/teachers/fact_sheets.html#generic (generic career fact sheets)



Student Information

Task Cards for Careers

Engineer Task Card

Your responsibility is to investigate the design and construction of ISS components that will support astronauts living and working in space. Think about what materials you will need, and work with scientists and astronauts to determine priorities of power, life support and other requirements. Report on what international partners are currently doing to prepare for ISS.

- What does it take to become an engineer for the ISS?
- How are ISS engineers currently training for the missions?
- What role might you play in how meals are determined for Space Station?

Internet Resource

Space Station Home Page

<http://spaceflight.nasa.gov/station>

Scientist Task Card

Your responsibility is to investigate the types of research proposed for the Space Station. Report on how microgravity will benefit this research, and how this research will benefit life on earth. Work with engineers and astronauts to investigate how research will be conducted differently on ISS, considering weight, size, and power restrictions, as well as, the human interaction required.

- What does it take to become a scientist for the ISS?
- How are ISS scientists currently planning for the missions?
- What role might you play in how meals are determined for Space Station?
- What effects does microgravity have on the body?

Internet Resource:

Space Station Science

<http://spaceflight.nasa.gov/station/science/index.html>

Scientist Task Card

Your responsibility is to investigate the types of research proposed for the Space Station. Report on how microgravity will benefit this research, and how this research will benefit life on earth. Work with engineers and astronauts to investigate how research will be conducted differently on ISS, considering weight, size, and power restrictions, as well as, the human interaction required.

- What does it take to become a scientist for the ISS?
- How are ISS scientists currently planning for the missions?
- What role might you play in how meals are determined for Space Station?
- What effects does microgravity have on the body?

Internet Resource:

Space Station Science

<http://spaceflight.nasa.gov/station/science/index.html>

Activity Two

SOCIAL STUDIES

Objective:

Practice reading longitude and latitude as well as exploring sighting days and times for the ISS at specific locations.

Materials:

Computer with Internet access, world map or atlas, pencil, and chart to fill in.

Estimated Time:

60 minutes

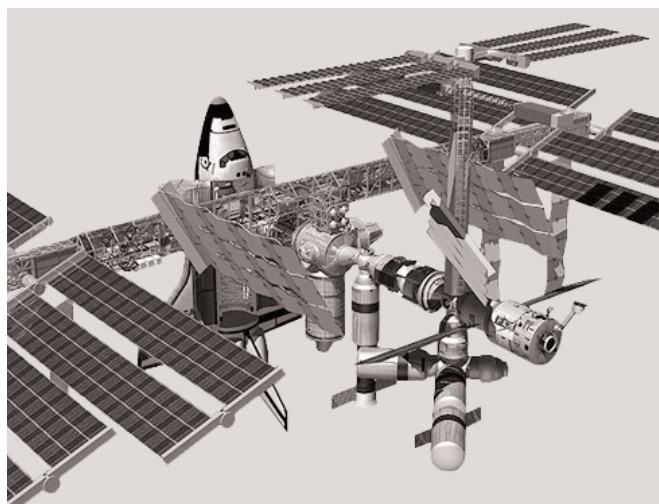
Background

If you look in the sky at the right time and right place, you can see the International Space

Station. Except for the Moon, it's the brightest object in the nighttime sky. The Space Station is in orbit at about 250 miles above the Earth's surface, and moves at about 17,000 miles an hour. Moving at that speed results in the ISS making about 16 complete trips around the Earth each day. The Space Station remains visible in any given section of the sky for 10 minutes or less. If it's not moving it's not the ISS. It moves at approximately the same rate as an airplane, but an airplane blinks. And a plane follows a linear path. The Space Station follows an arc. If you live in the 60 to -60 degree latitudes, you've got the best circumstances to view the ISS and that's just about everyone in America. For sighting information, go to: <http://spaceflight.nasa.gov/realdatasightings/index.html>.

Procedure/Activity:

1. Review latitude and longitude and how to use an atlas.
2. Give students the chart to locate places and fill in the name of the city for each longitude and latitude.
3. Next, have students go to the j-track web site: <http://spaceflight.nasa.gov/realdata/sightings/index.html> and find the day and time the Space Station can be seen at this location (have them choose three days - the same three days - for all locations.)
4. **Extension:** Students can create a graph showing the times and days for each location (locations can be color coded).



Rationale:

This lesson will strengthen latitude and longitude skill as well as create interest in locating the ISS in the sky.

Assessment:

Students will be evaluated according to accuracy in identifying and labeling the cities from the chart.

Additional Information:

- ESL students can locate places with the help of the ESL teacher or another student.

- Special Education students can locate fewer places (half of the chart).
- Website: <http://liftoff.msfc.nasa.gov/realtime/jtrack/spacecraft.html> (Skywatch - see satellite paths over the Earth).
- Website concerning longitude and latitude - <http://www.infoplease.com/homework/latlongfaq.html>
- Website for maps: <http://www.eduplace.com/ss/maps/index.html>

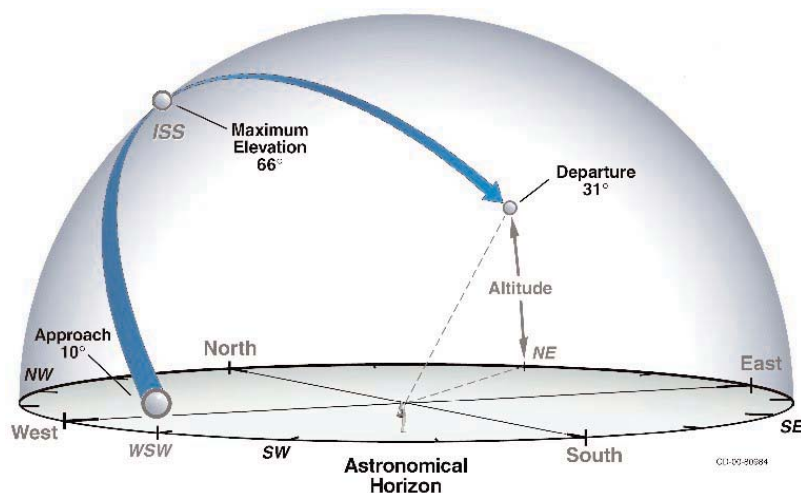
Student/Cadet Information

Materials:

Computer with Internet access, world map or atlas, pencil, and chart to fill in.

Directions:

1. Review latitude and longitude and how to use an atlas with your teacher.
2. Get the chart to locate places and fill in the name of the city for each longitude and latitude.



Place a mark on the map for each location.

3. Go to the j-track web site: <http://spaceflight.nasa.gov/realdata/sightings/index.html> and find the day and time the Space Station can be seen at each location (choose three days - the same three days - for all locations.)
4. Extension: Create a graph showing the times and days for each location (locations can be color coded).

Name: _____ Date: _____

Web site: <http://spaceflight.nasa.gov/realdata/sightings/index.html>

Latitude	Longitude	Location	Date(s)	Corresponding Time(s)
57:12:00 N	2:12:00 W			
33:45:46 N	84:25:21 W			
39:55:00 N	116:23:00 E			
33:31:40 N	86:47:57 W			
42:20:10 N	71:01:04 W			
42:53:23 N	78:51:35 W			
53:30:00 N	113:30:00 W			
53:34:00 N	10:02:00 E			
58:23:19 N	134:08:00 W			
38:42:00 N	9:05:00 W			
36:36:05 N	121:52:54 W			
40:46:38 N	111:55:48 W			
30:18:21 N	97:45:02 W			
18:58:00 N	72:50:00 E			
34:20:00 S	58:30:00 W			
30:00:00 N	31:17:00 E			
21:02:00 N	105:51:00 E			
41:02:00 N	29:00:00 E			
37:52:00 S	145:08:00 E			
48:13:00 N	16:22:00 E			

On a world map, place an X on the cities in this chart.

Activity Three

A SIGN OF THE TIMES

Procedure:

Develop a time line from the list of important events below. Review your CAP aerospace education products to remind yourself of many of these events. Use the internet or other textbooks to learn more about the events that are not included in your CAP books.

Develop your time line. Of course, it is your time line, so if you want to add or subtract events you certainly can. For easy reference, consider hanging the time line on a wall, a shelf or place it on a table.

Important Events:

- 1870 American writer Edward Everett Hale published a science fiction tale called "The Brick Moon" in the Atlantic Monthly.
- 1903 Konstantin Tsiolkovsky wrote *Beyond the Planet Earth*.
- 1923 Hermann Oberth coined the term "Space Station."
- 1927 Robert Goddard launched the first liquid-fueled rocket.
- 1928 Herman Noordung published the first Space Station blueprint.
- 1942 German V-2 rocket developed and used.
- 1945 Wernher von Braun came to the US to build rockets for the US Army.
- 1952 In Collier's magazine articles, Wernher von Braun described a wheel-shaped Space Station reached by reusable winged spacecraft.
- 1955 Work began on the Baikonur launch site in central Asia.
- 1956 The world's first intercontinental ballistic missile lifted off from Baikonur.
- 1957 *Sputnik 1* launched from Baikonur.
- 1961 Yuri Gagarin launched in the *Vostok 1* capsule, becoming the first human in space.
- 1969 Neil Armstrong and Buzz Aldrin became the first humans to walk on the moon.
- 1971 The first Space Station in history, the Russian *Salyut 1*, reached orbit atop a Proton rocket.
- 1973 The US launched the *Skylab* Space Station atop a *Saturn V* rocket.
- 1974-1977 *Salyut 3, 4* are launched (also known as *Almaz Station*).
- 1977 *Salyut 6* launched.
- 1982 *Salyut 7* launched.
- 1984 President Ronald Reagan called for a Space Station that includes participation by US allies.
- 1985 Japan, Canada and the European Space Agency each signed a bilateral memorandum of understanding with the US for participation in the Space Station project.
- 1986 Space Station *Mir* initial element launched.
- 1988 Formal agreements were signed between the US and its Space Station partners.
- 1992 Russia joined the US and its partners in the International Space Station Program.
- 1995 The Shuttle-*Mir* Program, the first phase of the ISS, began.
- 1998 The first two elements of the ISS, *Zarya* and *Unity*, launched from Russia and the US.

Activity Four

WHERE IS THE ISS?

Go to www.liftoff.msfc.nasa.gov for J-Track. This site will track the ISS.

Activity Five

BUILDING THE ISS

OBJECTIVE

To introduce students/cadets to the International Space Station as a topic of study. The secondary objective is to build a model of the ISS that will hang in a classroom, or meeting site, in the form of a mobile.

BACKGROUND

The first module of the International Space Station, known as Zarya, was placed in orbit on the 20th of November, 1998, by a Russian Proton Launch system. On December 3, of that year, a second module, known as Unity, was put into orbit by our Space Shuttle and the two units were joined together.



This was the culmination of a long, turbulent process of funding problems and international cooperation. Actual planning began in the Eighties; however dominance of the program by the U.S. didn't set well with many of the countries scheduled to be involved in the project. Over a period of several years, projected costs forced many of the potential partner nations to withdraw support and funding. A continuous down sizing and arguments over its mission almost brought about cancellation of the project.

In 1993, President Clinton gave NASA the task of reorganizing and restructuring the ISS program. Using expertise and existing space hardware, the US and Russia were able to cut projected costs by

nearly 40%. The U.S. was able to negotiate an agreement with Russia as a result of this new partnership-the former Soviet Union agreed to stop the sale of ballistic missile components to other countries and to maintain strict control over the export of strategic weapons technology. Another benefit was the expertise and technology gained by the Russians from their experience in long term manned flight aboard the MIR space station. If all goes according to plan, a fully operational Space Station will be ready by the year 2004.

MATERIALS

Build this in stages; however, it is recommended that you get all of the supplies together ahead of time. These include:

- a. At least a dozen long bamboo skewer sticks. These can be purchased at grocery stores.
- b. One or two large soda straws are required.
- c. 6-8 foam meat trays, preferably the ones that have one side "waffled." Usually, meat markets have these available. If you will shop around, waffled trays can be found in blue and that makes the **PV array panels** more realistic!
- d. A length of pipe foam insulation, similar to the kind used in the Goddard Rocket, will be needed to make the modules. Toilet paper or kitchen paper towel cylinders can be used for modules.
- e. The tubular modules can be capped with black or gray 35mm film canister caps.
- f. A roll of high-strength packaging tape will be used to hold the "station" parts together.
- g. A length of nylon fish line can be used to hang the ISS from a ceiling in a classroom or CAP squadron.
- h. Hot glue guns can be used to bond tubes and end caps.
- i. Epoxy glue works very well to bond areas that tend to get broken easily.

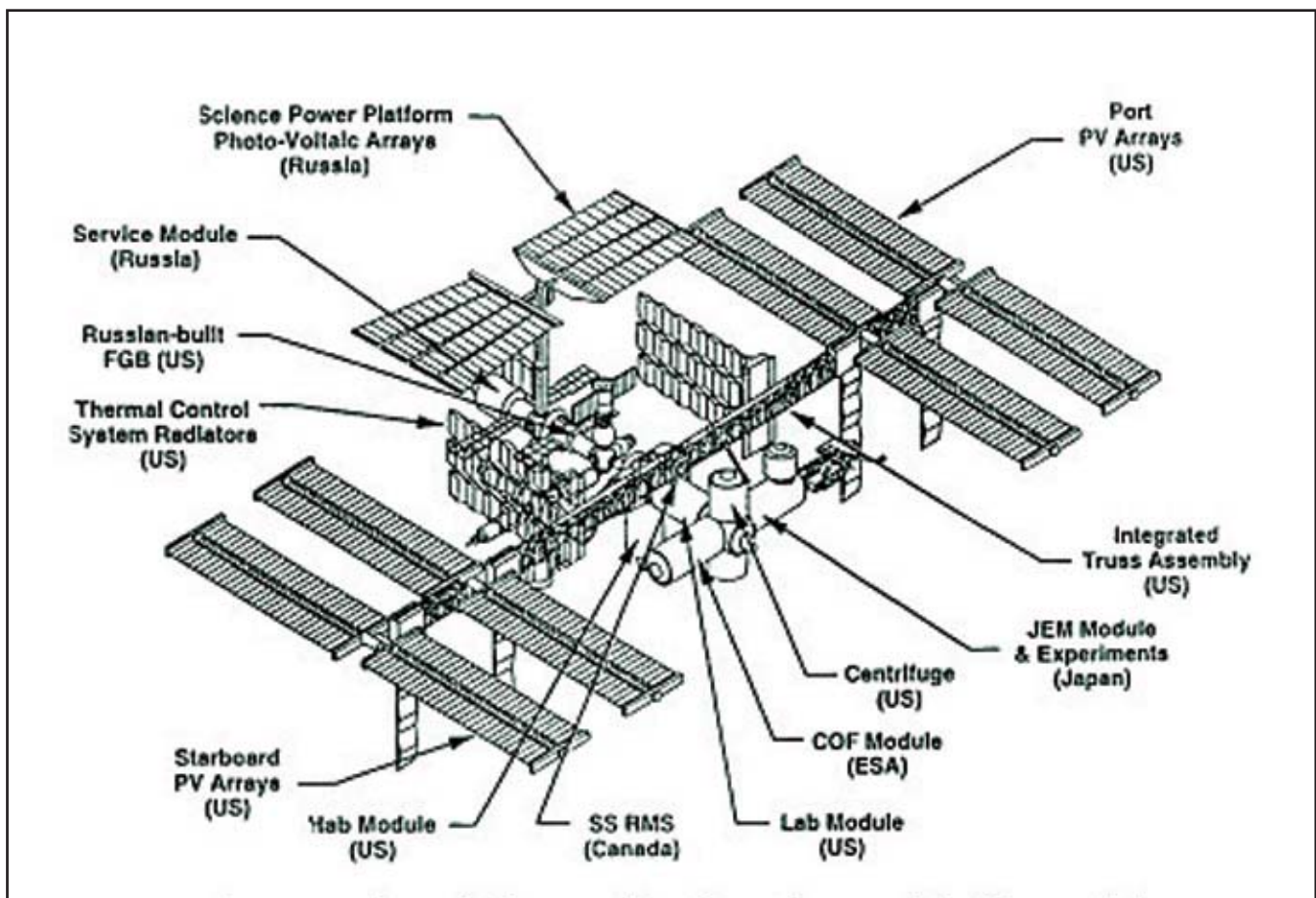
PROCEDURE

You are urged to follow this sequence of construction:

1. The bamboo skewer sticks are "stacked" together for the **integratedtruss assem-**

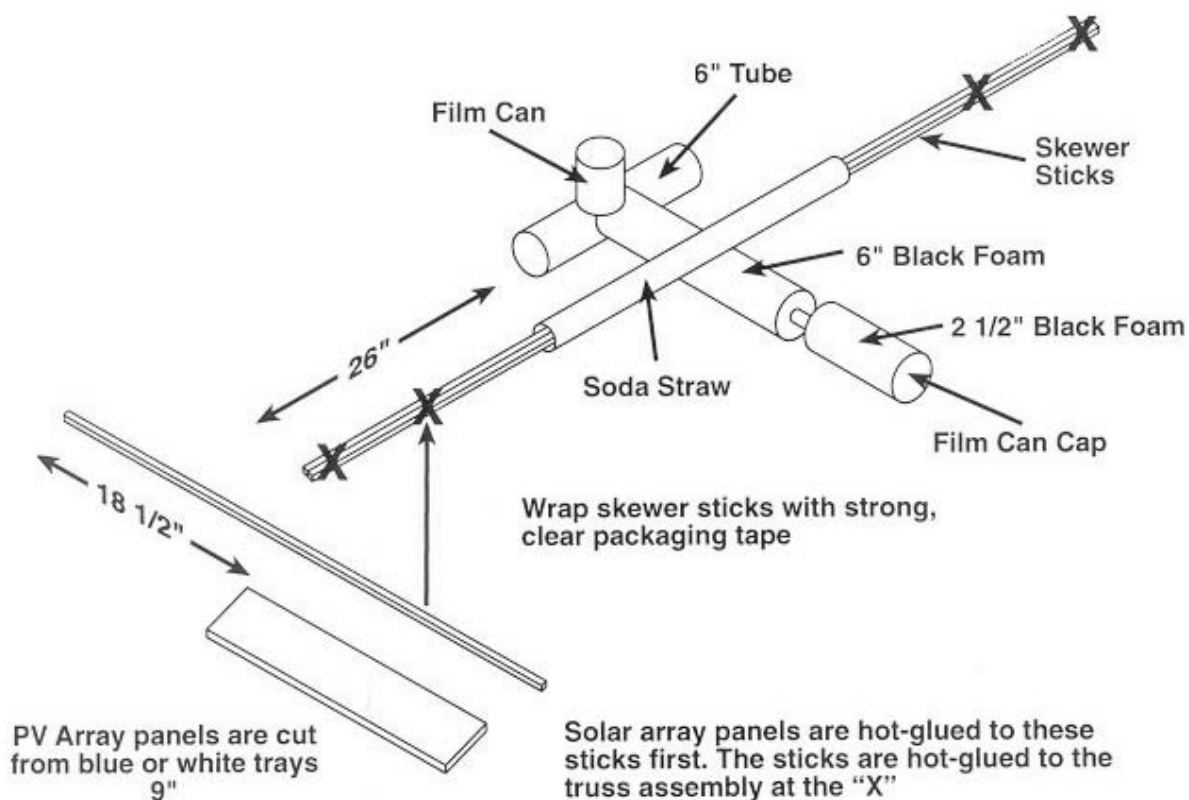
bly component shown in the "International Space Station Assembly Complete" illustration.

2. These skewer sticks (4-6) are first taped together in the center to hold them in a bundle. This is done by wrapping them with a long, single piece of packaging tape.
3. If your bundle isn't too bulky, you should be able to push a large soda straw over the bundle covering the tape. Check the illustration and you will see how it is supposed to look at this stage.
4. Using a hot glue gun, bond four skewer sticks at the positions shown on the illustration. These will be the frames for attaching the *PV Array Panels*.
5. Cut out at least 8 *PV Array Panels* from your supply of foam meat trays. These are 9 inches long and about 2 inches wide.
6. The *PV Array Panels* are bonded to the bamboo skewer sticks as shown in the illustration.
7. Lengths of pipe foam tubing are used to make the main modules. Use the illustration as a guide.
8. Film canister lids are used to "cap" the open foam tube "modules."
9. Using the ISS Assembly Complete illustration as a guide, students can make more modules and arrays to improve accuracy.
10. Once complete, nylon fish line can be used to hang this replica in a classroom.



International Space Station Illustration

This is the most current layout of the International Space Station. It should be noted that ISS assembly launches are on hold awaiting the Space Shuttle's return to flight following the Columbia's tragic loss.



This is a guide to the basic construction of the ISS. It is recommended that teachers and AEOs build the Station in stages so that students can study each module as an individual lesson. Cylinders made of cardstock or those found in paper products work quite well. Foam tubing was used because it is very light and weight is a factor in how the ISS "mobile" will look when completed. (Illustration by Seth Stewart.)

Discussion

1. By using library, or Internet sources, students can study each component as it is built into the ISS.
2. This project can be expanded using clear plastic soda pop bottles. The smaller Coke® or Pepsi® bottles can be used instead of the foam pipe insulation material. Bamboo is very strong and will support quite a bit of weight. To keep the main Integrated Truss Assembly from bending with the additional weight, it is recommended that more sticks be used.
3. Each of the larger bottles can be filled with tiny "Astronauts" and equipment so that stu-

dents can see how each module is being used. The complexity depends upon the age level of students involved in the project.

4. Teachers and AEOs are urged to use the "Gallery" section of Boeing's web site to see some very dramatic images of the Space Station. This site has a tremendous amount of information about the ISS.

Activity Six

"PUFFY HEAD, BIRD LEGS"

Human Physiology In Space

OBJECTIVE

This activity will make you aware of the changes that the human body experiences in space flight.

CREDIT- Human Physiology in Space (pp 63-66) by R. J. White & B.F. Lujan, NASA Life and Biomedical Science and Applications Division, 1994. Online at:
<http://www.nsbri.org/HumanPhysSpace/>

Ms. Lauren Allwein, aerospace teacher at the Nationally-acclaimed Euclid Middle School, Littleton, Colorado, attended an extensive summer course put on by the Baylor University College of Medicine. This course is known as "From Outerspace To Innerspace" and has the theme, "What can we learn in space about bodies here on Earth?" This outstanding program is highly recommended by the Civil Air Patrol's Aerospace Education Division. For more information about the National Space Biomedical Research Institute K-8 education Programs, please contact the Center for Education Outreach Baylor College of Medicine, Houston, Texas. 800-798-8244 or visit the NSBRI Web site at www.nsbri.org.

BACKGROUND

All astronauts and cosmonauts experience a phenomenon known as the "Puffy-Head, Bird Legs" When in a condition of microgravity, astronauts report a feeling of "stuffiness" especially in the sinuses, and a "fullness" in the head. There is also a puffiness of the face and this can be easily measured. Where aerospace medical specialists measure various parts of the body, such as face and legs, it clearly shows that changes occur in the shape of the legs. Astronauts call this condition "bird legs."

Measurements taken of the leg circumference during space flight on astronauts with larger legs show a proportionally larger decrease in leg volume than those with smaller legs. This is

explained by the fact that the more muscle a person has in the his/her limbs, the more fluid and blood flow is required to nourish those muscles. The more fluid and blood there is, the more there is to lose. It has shown that a fluid shift actually begins during the launch sequence. This is due to the astronaut having been seated in the space shuttle in a reclining position with his/her legs elevated, sometimes for several hours prior to launch.

PROCEDURE

In this activity, the students will break out into teams of three. Two will be the aeromedical scientists and the other will be the astronaut. A piece of tape (like masking) and a soft tape measure (found at fabric stores) will be used to make the measurements. Data will be collected from measurements of the astronaut standing and reclining. It might be pointed out that during the early portions of the head-down orientation, a student's stroke volume increases from about 75 ml/beat to about 90 ml./beat. This is entirely expected because there is a rush of fluids to the upper part of the body and the heart then has more blood to force out during each beat. In addition, to compensate for this increase in stroke volume (to keep cardiac output relatively stable), the subject's heart rate decreases. Therefore, during the portion of this student investigation where you are determining cardiac output, don't be surprised when you obtain lower values for the subject's heart rate. This is normal.



Students are given a full briefing before beginning the activity. If they know the importance of the data gathered, they will tend to take it more seriously.



1. Student Joe Winne volunteered to become the astronaut. Teacher Lauren Allwein places a piece of masking tape on his forehead, and this will become the point where measurements are taken. This tape is left in position throughout the experiment.



2. A similar piece of tape is placed on the subject's calf muscle. This will be the point where another source of data is gathered.



3. Chelsea Frommer and Rachel Winne carefully measure Joe's forehead in a standing position. It is important to get accurate circumference measurements from the test subject's leg and forehead in mil-

limeters. Have the person(s) doing the measuring be accurate and record the data on a data table. Be neat and make sure that numbers are accurate.



4. The next step is to get an accurate standing pulse rate. The scientists at the Baylor College of Medicine say, "...To get the test subject's STANDING pulse, have the test subject stand up for 3 minutes, then sit down and the 'pulse taker' should take the test subject's pulse for 15 seconds. Multiply this pulse rate times 4 to get the standing pulse rate. Record this pulse on the data table in the 'standing pulse rate' box."



5. The astronaut is allowed to lie down with his feet propped up on a chair. A timer should begin timing for 5 minutes. Record the starting time. After 5 minutes have passed, while the test subject is still lying down, remeasure the calf and forehead in millimeters on the

tape in exactly the same spot. Be accurate. Record this measurement in the "after 5 minutes-head down-feet up" calf and forehead boxes. While the test subject is still lying down, observe his facial characteristics and record these on the data sheet in the "facial observations after 5 minutes" box. While the test



subject is still lying down, question him about this own feelings or sensations. Record these sensations under "test subjects sensations after 5 minutes" box on the data sheet. Again, while the test subject is still lying down, take his pulse for 15 seconds. Multiply this pulse by 4 and record it on the data sheet under "pulse rate after 5 minutes."



The same procedure can be repeated for 10 minutes, 15 minutes and 20 minutes. All of the measurements are recorded and a conclusion is made regarding fluid shifts in the body during standing and reclining positions.